A Web-based Surveillance System for Mobile Phones

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ABSTRACT

A web-based surveillance system has been developed, which is organized with network cameras, an integrated web/mail server, mobile computing devices as GUI and remote control devices. Some kinds of devices can be used as its clients including, for example, high-performance mobile phone , which are equipped with Java virtual machine and web-browsing facilities. The surveillance system can obtain JPEG images from network cameras, process them, and accumulate them into its database. It can also receive requests from its clients, analyze them and perform previously defined services for remote monitoring and/or controlling. Image processing function is built in the system and useful for object's motion detection. Emergency contact for mobile phone can be realized by means of the surveillance system and its image processing facility. Additionally, a remote controlling function is available to switch electric power of appliances on/off. And brief evaluation of the system is also reported in this paper.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous; D.2.m [**Software Engineering**]: Miscellaneous—*Rapid prototyping, Reusable software*

General Terms

Design, Experimentation, Performance

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MOBILWARE 2008, February 13-15, Innsbruck, Austria

DOI 10.4108/ICST.MOBILWARE2008.2801

Keywords

Web-based Surveillance System, Remote Control Facilities, Usage of PDA and mobile phone as GUI, Image processing for detection of motion capturing, Java programming for server and client software.

1. INTRODUCTION

Unfortunately, contemporary society gets suffering from lack of daily life safety and needing some kind of monitoring and surveillance services in order to achieve global security. Applications of image processing techniques in surveillance fields had been reported in some remarkable articles such as [1], [2] and so on. And there are several researches and reports about the surveillance system [4], [7], [11]. Monitoring cameras are specially playing an important role in a surveillance system. So there are some researches about monitoring cameras [12].

By the way, server-client computing is one of the most attractive solutions to realize efficient information systems. As respects surveillance system, a client-side computing device has a decisive influence on its total performance of surveillance system. Mobile devices make progress more and more [3], [6]. Usage of a mobile phone as a client of surveillance system is a good way, because of its portability and ubiquitous computing, namely monitoring anytime and anywhere.

A web-based surveillance system has been developed, which is designed to perform its capability with mobile phone as its client-side computing device, and applied into an autonomic monitoring application. Detection of object motion and emergency contactcan be realized with its built-in simple image processing function.And switching electric power of appliances is also available though its remote controlling function.

This paper presents related works and problems of our previous monitoring system, at first. An overview of the new version of our surveillance system and its functions are described in the next section. Additionally, services from our new surveillance system are illustrated and brief evaluation about it with mobile phone as its client is also reported. Finally, summarized description about our system is located as a conclusion.

2. RELATED WORKS

It is the very matter of concern how to acquire our security. Monitoring facilities have been necessary and useful for our daily life, because it is very important for us to think about our security[4]. This section deals with related re-

search and reports about surveillance system s and several techniques to make advance of their performance.

2.1 Related Researches and Reports

We have selected three researching articles about surveillance systems and then two researching ones about mobile phones.

At first, an article "A distributed visual surveillance system [5]" told us how to improve the score of detection about several intrusions as follows; The distributed vision-based surveillance system acquired and processed gray level images through one or multiple camera units monitoring certain area via a local area network and was capable of combining information from multiple camera units to obtain a consensus decision.

It could be trained to detect several types of intrusions and minimized false alerts due to other non-interested intrusions. The authors tested their system in an unconstrained outdoor environment and illustrated good performance.

Article "Multimedia surveillance systems[11]" suggested us how to provide an automatic analysis of the controlled environment and a real-time interpretation as follows; The integration of video information and sensor networks constituted the fundamental infrastructure for new generations of multimedia surveillance systems, where many different media streams such as audio, video, images and sensor signals would concur to provide an automatic analysis of the controlled environment and a real-time interpretation of the scene.

Authors' solutions could be devised to enlarge the view of traditional surveillance systems by means of distributed architectures with fixed and active cameras, to enhance their view with other sensed data, to explore multi-resolution views with zooming and omni directional cameras. Applications regarded surveillance of wide indoor and outdoor area and particularly people surveillance.

And then an article "Improving the effectiveness of monitoring and control systems exploiting knowledge-based approaches[10]" taught us how to adopt artificial intelligence into surveillance and improve the performance of monitoring and control systems (MCSs) as follows; Authors said that traditional MCSs were designed according to a three-level architectural pattern in which intelligent devices were usually devoted to evaluate whether the data acquired by a set of sensors could be interpreted as anomalous or not. Possible mistakes in the evaluation process, due to faulty sensors or external factors, could cause the generation of undesirable false alarms.

To solve such a problem, the above traditional three-tier architecture of MCSs had been extended with a fourth level, where an intelligent module, usually a knowledge-based system, collected the local interpretations made by each evaluation device, building a global view of the monitored field. In this way, possible local mistakes were identified by the comparison with other local interpretations.

An article "Secondary user relations in emerging mobile computing environments[13]" reports usage of mobile phones and mobile technology in a study of a U.K. regional Fire and Rescue Service.

And finally, an article "The dynamics of control and mobile computing in distributed activities[14]" illustrates as follows; Mobile technologies are increasingly finding a place in a multitude of organizational settings. As they are intimately associated with the individuals carrying them, they can potentially play a significant role in the remote control of activities.

2.2 Our Previous System

In the second half of this section, we have introduced the previous version of our monitoring system[8]. According to the correspondence from client, it received the request, analyze it and send the special signal to a control subserver in order to switch on the electric power line or off. Moreover e-mail transmission service was available, too.

Our integrated server also plays a role to provide some kind of gateway services in order to exchange information and/or message between private network side and global one. These were key concepts to design our previous monitoring system.In order to take more advantage of surveillance application, the following problems should be resolved.

- Almost clients always want to investigate whether their related objects are safe or not.
- Emergency contact needs that 24-hour surveillance and detection of object motion.
- mobile phone is suitable enough to be carried with clients and provide smart and useful GUI for autonomous surveillance.
- Our previous system had been organized with Apache (famous httpd software). But it was heavy and difficult to manipulate, reduce its some functions, which is not necessary, and build in other useful functions.

Based on the above studies about related works and self-examination about our previous monitoring system, we have decided to reorganize and reconstruct our previous system into a new version of surveillance system. The system will be introduced in the next section. And its detail functions will be also illustrated.

3. SYSTEM CONFIGURATION

This section describes system configuration about the new version of our surveillance system [9] and its procedures, which include transmission, accumulation and reduction of image obtained from network camera, remote control for appliances with Java programming and signal transmission through electric power line and browsing of images on GUI of mobile devices.

3.1 Java Web Server for Surveillance System

The integrated server of our surveillance system has been implemented on a Linux machine and almost all of its application software are written in Java programming language. Such software may be divided into some modules, which were designed based on the way of server-client computing model.

Modules for server are written as stand-alone applications of Java, while others for clients were basically implemented as Java applets as well as Java application programs for mobile computing devices. Our surveillance system employs Java applet for client software construction because of its capability to be constituted for different kinds of clients, transferred from server to each type of client through HTTP connectivity

Almost all software of our surveillance system have been written in Java programming language, because of easy and powerful description of GUI as well as network programming. We have decided to develop Java-based Web server software (**Java Web Server**) with several functions written in pure Java language. With this **Java Web Server** , the major part of software for our surveillance system can be efficiently realized so that prototype of our new surveillance system has been developed in a short period.

And it is very much easy to customize and build in many applications and execution modules as external subroutines and/or threads of **Java Web Server** .Image processing function has been also implemented as an external thread of it.

3.2 Monitoring Facilities

Java Web Server can periodically obtain images from some network cameras through the private network. Such images are transmitted from camera to server by means of HTTP-based communication procedure. They are accumulated as JPEG images temporally into the internal buffer of server, reduced into a fourth and a ninth resized image data and finally stored into image database. Reduction of such mages had better be performed for some mobile devices, not only because some mobile devices allow only restricted amount of packet size between server and themselves, but also because they have relatively narrow sizes of display LCD. Figure1 shows a scheme of our remote monitoring procedure.

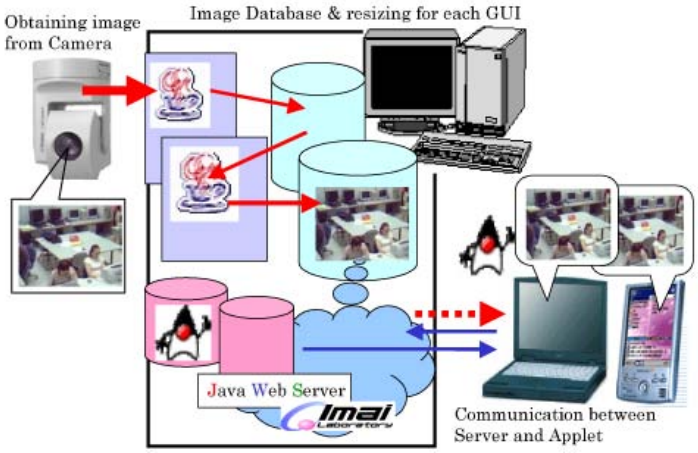

Figure 1: Schema of Obtaining Image from Network Camera and Processing it for the several types of Client of Monitoring System

In order to realize remote monitoring, it is absolutely necessary to obtain several kinds of images. Although animated (moving) pictures would be much more effective to make a suitable decision about the target situation than stationary ones, our system can only deal with continuously stationary pictures still now. **Java Web Server** requires network camera to transmit JPEG images at a sampling rate, receives such images as monitoring view, reduces size of images and then accumulates a series of them in the storage. The server also prepares Java Applet on its homepage, waits for clients' access from global network and then delivers such an Applet to the target client.

At the side of client, Java Applet downloaded from our server provides a GUI which communicates server to request transmitting JPEG image by means of HTTP connection and display received JPEG data file on the browser in the mode of stationary image or continuously alternating images like as slide show. In the case of later mode, Applet prefetches JPEG data from server, stores and preload in the double-buffering style, and realize quasi-moving picture on the display of PC's browsers or PDA's ones.

3.3 GUI Services for Mobile Phone

With Java applet, clients can browse monitoring quasi-moving image obtained from network camera on their browser of PC through **Java Web Server** .But it has seemed to be more effective and convenient for clients to browse such images with their mobile phones, because almost all people of Japan always carry their mobile phones together with them.

One of various Java technologies, for example CLDC (Connected Limited Device Configuration) of Java 2 Micro Edition, allows us to utilize relatively small sizes of Java program (or Java application) on the specific mobile phones, and then it can be downloaded from **Java Web Server** and perform a mobile communication based on HTTP connection between server and mobile phones.

Java Web Server has prepared such a Java applet on its homepage, deliver it into clients' mobile phone according their requests, and communicate it in order to transmit monitoring images and allow mobile phones to browse them. As there are some constraints on the image data size, which mobile phones can accept at the one time, for both of transmission and display of it, then **Java Web Server** must reduce JPEG images from network camera into a suitable size for mobile phones and accumulate these images in its storage for request of image delivery from mobile phones.

In order to reduce useless traffic cost between mobile phone and **Java Web Server** , client of mobile phone must make sure to push the bottom for obtaining the next image from the Server.

3.4 Control Facilities

Remote control service seems to be essential for supplementing remote monitoring service and enlarging it into wide application. Various control mechanisms have been proposed and this time we employ power switching facility as remote controlling function of the surveillance system. Figure2 shows a scheme of our remote control procedure.

OpenPLANET control server is connected to **Java Web Server** in the private network. It works as sub-server in our monitoring system. It has a dedicated interface to connect serially with the Electric Power Line Router (EPLR). It is the special-purpose microcomputer-based device, which can translate digital information into analog signal and mix it along electric power line. With EPLR, digital information of OpenPLANET server can be carried to another computer only by means of electric power line within single electric power distribution board. So we need not to equip additional cable to transmit digital information between controller and the target node to be controlled.

Power Control Adaptor (PCA) is the special-purpose power outlet based on OpenPLANET technology, which can turn on or off electric power according to analog control signal from remote controller via electric power line. The Open PLANET server provides remote control facilities to per-

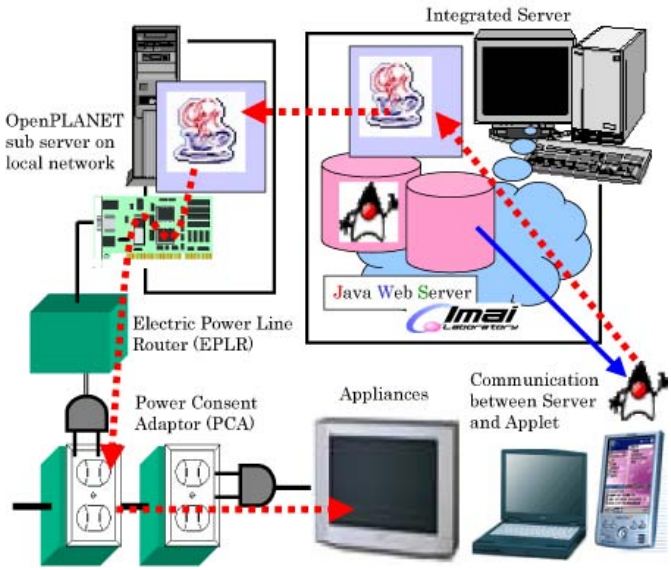

Figure 2: Schema of Controlling Appiance through our Monitoring System

form electric power switching by means of transmitting control signal for digital information into PCA with EPLR.

Java Web Server has a connection with such an OpenPLANET server, sends and receives socket-based messages to/from such a server, and performs remote control service for electric power switching through private networking. Communication between our Server and OpenPLANET server is carried out based on TCP/IP protocol and software for their communication is written in Java programming language. Java codes can be executed not only on **Java Web Server** but also on the OpenPLANET server.

Client users can enjoy remote control service from **Java Web Server** if they request Java applet download from the server to do power switching. Such a Java applet communicates with its Server to allow OpenPLANET control sub-server to perform the above control mechanism.

4. SYSTEM EVALUATION

This section describes practical application services by means of current version of our surveillance system. At first, current state of our surveillance system is mentioned. Secondly, by means of image processing for monitored data, it is illustrated whether remarkable changes between continuous sampled images happen or not. And brief evaluation of our system's performance is shown at the end of this section.

4.1 Current State of our Surveillance System

At the present of our prototype system, the following services are available in our monitoring system;

Image Transmission Service: A series of JPEG image file can be periodically taken by network camera, transmitted into **Java Web Server** , and accumulated with simple image resizing procedure in the storage of that server. Request to obtain the buffered image in **Java Web Server** causes transmission of such image into the browser of client PC, process of Java Applet for downloaded images, and display images on the browser in the manner of stationary picture and/or quasi-moving picture.

Remote Control Service: The Open PLANET server can perform remote control for electrical device through electric power supply line. Our surveillance system has incorporated this server into the lower layer of **Java Web Server** in the private network, which means that system permit no direct access into the Open PLANET server from global network. **Java Web Server** communicate to ask the Open PLANET server to perform the control service according to the request to control several kinds of electric device and appliance.

Display Image on LCD of Mobile Phone: This facility is only available in the mobile phone ("keitai" of Japan) from the specific carrier, namely NTT DoCoMo[6]. Although NTT DoCoMo is one of the major carrier of Japan, we must do best efforts for our system to be more applicable in order to utilize other types of mobile phone from other carriers. Current LCD size of mobile phone seems to be not suitable to display the image for remote monitoring. Of course, mobile phone is very much convenient to be carried with user, so we must expand the facilities of our system such as zooming and scrolling for small image and/or large one. In the very near future, we must develop Java programs for CLDC+MIDP (Mobile Information Device Profile) -based mobile phone in addition of i-mode Java programming application (called "i-αppli")for NTT DoCoMo.

4.2 Image Processing and E-mail service

Users whose e-mail addresses have been entered in our Integrated Server can receive e-mails about some kinds of message from the server, when monitoring system recognizes whether a situation of target system needs sending message, such as emergency contact or not. Our message mailing service covers the following two cases; namely,

- Normal e-mail transmission service, which includes sending message to such personal computers connected to wired/wireless LAN.
- Mobile e-mail transmission service, which deals with mobile phone and/or PHS through global communication network.

In the former case, generally speaking, e-mail is one of the most usual message transmission methods between computer's users of LAN and the Internet. And the message to be sent may contain description of a special URL, which tells users to get information about image, control scheme and Java applet. With such information, clients can access a suitable resource for them to steer the monitoring system efficiently. Figure3 shows a scheme of our message mailing service with cooperation of image recognition procedure.

On the other hand, clients sometimes leave their seats where they sit down and work with computers. They will carry mobile phones or PHS's with them, however, even at such a situation. In the later case, a mobile phone provides wide area of e-mail service to clients, so that message from server can be delivered to the target clients no matter where they are.

It is very much useful for emergency message to be sent to clients when monitoring system and clients decide to utilize e-mail service of mobile phone and PHS. With such a

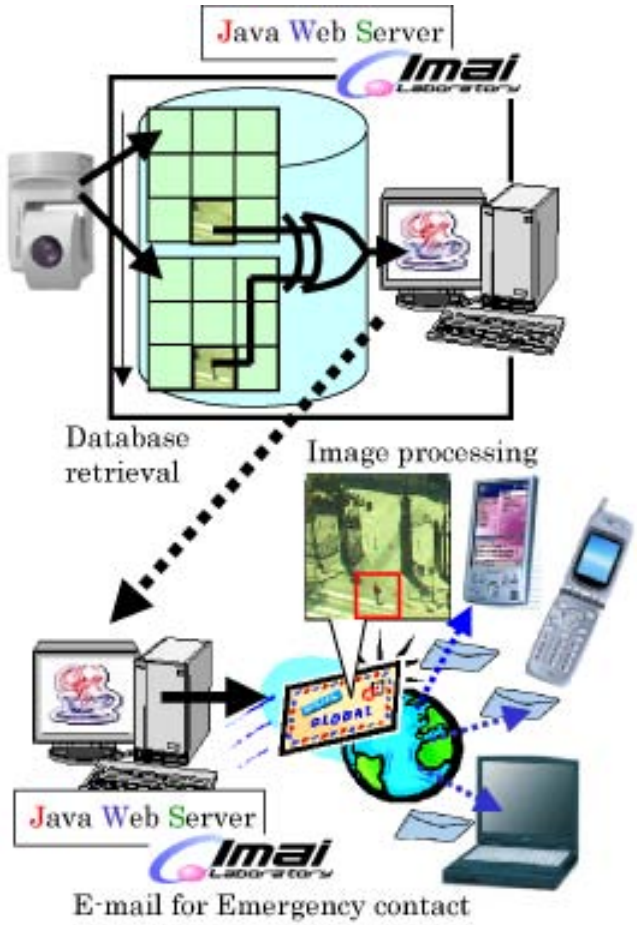

Figure 3: Schema of Image Processing with Database and Detection of Image chances

message mailing service, some emergency call can be realized as follows; **Java Web Server** periodically obtains a series of images from network cameras. When a new image is partially different from the previous one, image recognition procedure, which has been already invoked, investigates whether the target two images have a certain difference on a fourth or a ninth of whole image or not.

If such a procedure proves some difference between two images, **Java Web Server** recognizes that some change of images happens at the monitoring point, decides to send the suitable clients e-mail by means of the above message mailing service. **Java Web Server** has been customized to deal with function of a mail server directly. When image recognition procedure points out the difference between target images, the Server has sent e-mail to the previously entered clients with e-mail sending facilities. Especially, sending e-mail to mobile phone client is effectively because users almost always carry such mobile phones with themselves.

4.3 Brief Evaluation of Performance

Java Web Server has prepared such a Java applet on its homepage, deliver it into clients' mobile phone according their requests, and communicate it in order to transmit monitoring images and allow mobile phones to browse them.

As there are some constraints on the image data size, which mobile phones can accept at the one time, for both of transmission and display of it, then our server must reduce JPEG images from network camera into a suitable size for mobile phones and accumulate these images in its storage for request of image delivery from mobile phones.

Transmission times of not only an image but also a control signal are described as a trial evaluation of our system. First of both transmission times is the case of transmission time of an image. An image is obtained at network, stored in Server, and transmitted into a mobile phone, according to a request of a client. We measure 10 times of response time of an image, from pushing a button of phone to getting image on the display of the phone as transmission time of an image. The result is shown in Table1.

Table 1: Response Times of an Image and a Control through Wide Area Network of Mobile Phone

	response time for monitoring		response time for controlling	
measure times	total process time(ms)	server process time(ms)	total process time(ms)	server process time(ms)
1	2,060	30	2,220	1,332
2	5,000	40	2,650	1,422
3	5,890	40	2,590	1,332
4	6,440	30	2,750	1,482
5	4,940	40	2,590	1,350
6	3,370	30	2,570	1,292
7	7,100	40	2,750	1,513
8	5,180	40	2,750	1,452
9	6,560	30	2,630	1,472
10	4,350	35	2,590	1,432
average time	5,089	35	2,609	1,408

The average of transmission time of an image is 5,089 milliseconds (about 5 seconds). Maximum time is 7.10 seconds and minimum one is 2.06 seconds. Amount of image is 2.2-kilo bytes in that case.

A size of image to be transmitted is normal and almost constant in our system because such a monitoring image is obtained at network camera, periodically accumulated in **Java Web Server** , and reduced suitably for mobile phones. Due to Wide Area Network of mobile phone service, transmission times range, for example, from 2,060 milliseconds to 7,100 milliseconds. In almost case, however, clients of our surveillance system will be able to obtain the monitoring image and take a look at the display of mobile phone about under 10 seconds of response time.

The second case is transmission time of a control signal. The remote control is realized as follows: a request from a client is sent to **Java Web Server** of our surveillance system, recognized in it and transmitted into the target to be controlled through Open PLANET technology, described in the previous section. Just like the case of response time of an image, we also measure 10 times of response time of a control, from pushing button of phone and allowing target appliances to be switched into On/Off as transmission time of control. The result is also shown in Table1.

The average of transmission time of a control is 2,609 milliseconds (about 2.60 seconds). Maximum time is 2,750 and minimum one is 2,220. Compared with transmission of an image, transmission time of a control is relatively constant regardless of usage of Wide Area Network of mobile phone service. That is why control transmission needs very little amount of data to be sent from mobile phone to the target so that it may be relatively independent from network status.

Due to public and wide area network of mobile phone service, transmission times range, for example, from 2.06 seconds to 7.10 ones. In almost case, however, clients of our surveillance system will be able to obtain the monitoring image and take a look at the display of mobile phone about under 10 seconds of response time.

5. CONCLUSION

We have described design and tentative implementation of a distributed surveillance system. This system has been available to obtain image from network camera, perform power switching for electrical device and appliance and so that it can ensure reliable use of electric and/or mechanical systems. Our surveillance system contains several kinds of servers; **Java Web Server** is designed to play an intensive role to instruct and integrate its subsystems by means of network connectivity.

In our work, Web service mechanism and Java technology are essential keys to allow our system to be much useful to describe several server programs and smart GUI's, and network-oriented applications efficiently. Instead of **Java Web Server** , many sub-systems are organized, for example, network camera, remote sensors, remote switches and remote control devices. They can cooperatively work together to realize distributed monitoring system.

Mobile computing devices, especially, wireless portable PC's and/or mobile phones are useful for client users to communicate with monitoring and database server at any place as well as at any time. Remote monitoring and remote control are useful for improving system reliability, maintenance and some kinds of security. In order to realize such monitoring and controlling, it is available for constructing a Web-based surveillance system.

Acknowledgement

The authors would like to express the special thanks to Dr. Shin'ich Masuda, President of Cmicro Inc. for his continous and powerful support for our project. They are also very thankful to Mr. Daisuke Yamane and Mr. Makoto Ooga of Cmicro Inc. and Mr. Osamu Sadayuki of Sharp Business Computer Inc. for their several contributions of developing the previous version of our surveillance system. They are grateful to Mr. Hisashi Nagano and Mr. Shin-ichi Fujihara for their contributions about the OpenPLANET technology. They express our appreciations to Mr. Kazumasa Miyazaki of NTT DoCoMo Shikoku and Mr. Yoshio Saito of Vodafone Japan for their constructive advices to develop software for mobile phones, as the clients of our surveillance system.

This study was partly supported by Grand-in-Aid for scientific research from the Ministry of Education, Culture, Sports, Science and Technology under the contract No. 19500044. And a part of Dr. Hori's research of this paper is supported by the fund for Kagawa University Young Scientists 2007.

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